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BULLETIN No. 51

THE GUATEMALAN AVOCADO IN HAWAII

BY

W. T. POPE, Horticulturist

Issued August 16, 1924.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1924

HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU

[Under the supervision of the Office of Experiment Stations, United States Department of Agriculture.]

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THE GUATEMALAN AVOCADO IN HAWAII.

W. T. Pope, *Horticulturist.*

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INTRODUCTION.

The Hawaiian Islands, with their many cool yet frostless localities at varying elevations, uniformity of rainfall, and well-drained soils, are adapted to the culture of the avocado. The higher elevations are particularly suited to the growing of the Guatemalan avocado, which originated under similar conditions in the country of its name. This race of avocados has well-defined advantages over practically all other tree fruits in the Territory. In cultural requirements it is suited to considerable areas that are not now utilized for any other cultivated crops. At an early age it produces crops that mature in the winter season when the summer or West Indian avocados are not in market. The fruit has a rind which protects it from attacks of the Mediterranean fruit fly (*Ceratitis capitata*).[1] The fruit is characterized by its firm pulp, tight-fitting seed, and hard rind. It has a high food value and is considered by some horticulturists one of the greatest undeveloped tropical sources of food.[2]

The data presented in this bulletin represent the results of 20 years' work with the Guatemalan avocado at the Hawaii Experiment Station. The fruit has unlimited marketing possibilities on the mainland of the States and in other countries, as well as in Hawaii, and its cultivation should be extended.

[1] U. S. Dept. Agr. Bul. 536, The Mediterranean fruit fly in Hawaii, p. 44.
[2] Popenoe, Wilson. Manual of tropical and subtropical fruits, p. 9.

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HISTORY IN HAWAII.

According to records published by the Royal Agricultural Society,[3] the Guatemalan avocado was introduced into Hawaii probably early in the nineteenth century by Don Francisco de Paula Marin, a Spanish horticulturist. Published reports give Don Marin credit for having introduced many other valuable economic plants which he grew in his garden in Pauoa Valley, and in his "ka pa waina," or vineyard place, near what is now known as Vineyard Street, Honolulu.

Dr. William T. Brigham, of Honolulu, states that in the private journal of Doctor Bloxam, the naturalist of the *Blonde*, the British vessel which brought the remains of Kamehameha II and his wife to Honolulu, it is stated that the avocado and other fruits were found growing in Honolulu and vicinity in 1825. Very likely some of the fruit mentioned included introductions by Don Marin. Doctor Brigham further states that while botanizing in the Pauoa Valley in 1855 he found avocado trees bearing round, greenish-colored fruits which had rough rind, large seed, and rather fibrous flesh that was not generally liked by those who tried it. The description of the fruit corresponds with that of the Guatemalan avocados examined by the writer in the Pauoa Valley in 1902.

According to the statement of Judge Sanford P. Dole, a former governor of the Territory, the Guatemalan avocado has been growing in the valley of Pauoa for many years, but it is not as well known or as well liked as are the West Indian varieties which grow in other parts of the Territory. Some of these facts would seem to indicate that Don Marin brought his original seedlings from the west coast region of Central America. Their failure to become generally distributed is likely due to the poor quality of the fruit, improvement by cross-pollination with good varieties not being possible in the small valley of Pauoa,[4] and to the early introductions of better varieties of the West Indian race into other parts of Hawaii.

In 1853 the United States ship of war *Portsmouth* stopped at the ports of Hilo, Lahaina, and Honolulu, leaving seedling avocado trees from Central America. It is believed that this introduction was the first to have a wide influence upon the cultivation and distribution of the avocado in Hawaii.

In 1895 Rear Admiral L. A. Beardslee, commander of the Pacific naval forces of the United States, with headquarters at San Francisco, came to Honolulu on the flagship *Philadelphia*. It was on this visit that he introduced several Guatemalan avocado seedlings, the fruit having been brought to him in San Francisco just previous to his sailing for the Hawaiian Islands. On his arrival in Honolulu, January 30, 1895, he gave three of the germinating seeds, wrapped in moist cotton, to his friends Mrs. E. K. Wilder, Judge H. A. Wiedemann, and Judge J. W. Kalua.

The seed given to Mrs. Wilder was planted at her Esbank home in Nuuanu Valley, where the tree fruited and after a few years died. It is thought that none of the seed of this tree was planted.

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[3] An organization which flourished on the islands about the middle of the nineteenth century.

[4] The writer has found no evidence of the Guatemalan avocado of Pauoa Valley having influenced the growing or the quality of the avocado fruit in other parts of the Territory.

The seed given to Judge Wiedemann was grown on his premises in the Punahou district of Honolulu, 1402 Punahou Street, now occupied by the Macdonald Hotel. When the tree began to attract attention as a prolific bearer, it became known as the "Macdonald avocado," instead of the Wiedemann, as probably it should have been called. (Plate I.) The tree produces very rough, spherical, hard-shelled fruit in winter, and the flesh is rich and of excellent flavor. Many trees have been propagated from buds taken from the Macdonald, and it is now recognized as a distinct variety of Guatemalan-Hawaiian origin. The most interesting and valuable feature associated with its development is the superiority of a number of the progeny to the parent in nature of growth and quality of fruit.

The seed received by Judge Kalua was taken to Wailuku, Maui, where the tree is still growing. It also is a vigorous, prolific specimen which matures its fruit during the winter months. Several seedlings grown from the tree have excellent qualities and are described elsewhere in this bulletin. The station has propagated trees from buds taken from the Kalua Guatemalan avocado.

A number of new varieties of the Guatemalan avocado trees were received from the Office of Foreign Seed and Plant Introduction of the United States Department of Agriculture in 1919, and many have been received since. They represent a part of the valuable collection made by Wilson Popenoe, agricultural explorer, who spent many months in carefully exploring the highlands of Guatemala in search of the most promising types of avocados. These introductions are now growing at the Tantalus substation.

NOMENCLATURE.

COMMON NAMES.

The avocado was probably first referred to in literature as the "pear" or *peral* by Gonzalo Hernandez de Oviedo in his report to Charles V of Spain in 1526. He states, however, that the fruit is a pear in form but in nothing else.[5] Since that time the avocado has been called by numerous other names. Among English-speaking people the misnomer "alligator pear" is applied to it. Alphonse De Candolle, in his "Origin of Cultivated Plants," states that the name "avocado" is a corruption of the Mexican *ahuacate*, or *aguacate*, which in turn, Popenoe says, is an adaptation of the Aztec *ahuacatl*. In Chile, Peru, Ecuador, and in parts of Central America the fruit is commonly known as the *palta*.

BOTANICAL STATUS.

The avocado was first described by Linnæus in 1753 under the botanical name of *Laurus persea*. Miller, in 1768, placed it under the genus *Persea* and species *americana*. The genus Persea belongs to the laurel family (Lauraceæ) and is related to the cinnamon, camphor, sassafras, and California bay. *Persea americana* is also known by some horticulturists as *P. gratissima*. *P. americana* has become the most generally accepted name for the avocado, and under it may be listed all of the varieties known horticulturally as belonging to the West Indian, Guatemalan, and Mexican races. The

[5] Sumario de la natural historia de las Indias. (Biblioteca de autores españoles, historiadores primitivos de Indias, Madrid, 1852.)

characters serving to distinguish the different races horticulturally are shown in the following key:

(*a*) West Indian race. Summer and fall ripening; fruit large; rind leathery and not more than one-sixteenth inch in thickness.
(*b*) Guatemalan race. Winter and spring maturing; fruit large; rind one-sixteenth to one-fourth inch in thickness; woody in texture.
(*c*) Mexican race. Leaves small and anise scented; fruit small and thin-skinned.

CHARACTERS.

Habits of growth.—The Guatemalan avocado is exceedingly variable in its habits of growth, ranging in size in its native land from mere bushes to trees attaining a height of between 60 and 80 feet with trunks 3 to 4 feet in diameter. In Hawaii some 15-year old seedlings have large spreading tops reaching a height of 45 feet. In form the trees vary from slender and erect to broad and spreading. The branches differ in character of growth so far as brittleness, stiffness, and drooping habits are concerned, and the foliage varies in color and size of leaves. Some varieties yield a heavy crop each year and others only in alternate years. Climatic conditions may account for some of this variation.

Roots.—The taproot is rather pronounced in young seedling avocados, but it practically ceases to extend after the first two years of growth, and is a comparatively small portion of the root system. The secondary roots gradually become the anchorage of the tree and the main channels through which the food materials are conducted from the soil. They stretch out in all directions through the upper layer of the soil, even spreading farther horizontally than any of the branches of the top. The bulk of the roots feed between the eighth and the fortieth-inch levels, although as the tree grows they may penetrate much deeper in well-aerated soil.

Die-back, which manifests itself by yellowing of the shoots and the dying back of the new twigs for several inches, resulting in the early death of the trees, usually is attributed to the taproot's having reached rock or penetrated into black volcanic sand. This does not appear to be the reason, according to experiments conducted at the station. The present indications are that the difficulty is due to a combination of causes. Die-back may be prevented by giving the trees good culture and by taking care to plant them in a location that is not only well sheltered from hard winds but that has a soil rich in organic matter, and with good underdrainage.

In experimenting with the root system of the avocado the station found that a relatively large proportion of the root may be cut from budded trees at planting time without injuring them. Three or four year old trees may be successfully moved to a permanent place in the orchard provided they are properly handled. Transplanting must be done at the season of least rapid growth, and the roots should be covered with thoroughly dampened burlap bags for protection from the sun and wind. The tops must be cut back to correspond with the shortening of the roots that occurs when the trees are dug. The tree must be replanted as soon as possible.

Wood.—The wood of the avocado is soft, fine grained, and of a color varying from light brown to reddish brown. The heartwood is slightly mottled with light, curved spots of different colors. There is little evidence of annular rings of growth in cross-section, because

of the growth being general throughout the year. The bark of the tree is rather thick, rough, and of light gray color.

Leaves.—The leaves of the Guatemalan race of avocados are a rich, dark green in color, oval, oblong, or lanceolate in form, and from 3 to 10 inches in length. The upper surface is of deep green color and smooth, with depressed veins. The lower surface is glaucous or bluish-green colored, with raised veins which are slightly pubescent. Leaves of some varieties are thin and papery while those of others are thick and leathery. The crushed foliage of the Guatemalan race has no anise-like odor characteristic of the Mexican race of avocados and the new growth is usually of a deep bronze red, an occasional character of the new growth of the West Indian race.

Flowers.—The flowers are perfect and are borne in clusters of panicle arrangement, varying from open and spreading to closed and compact. The different forms of clusters vary with the different varieties of the race. They are small, of pale-green color, and finely pubescent. Each flower is perfect, having both staminate and pistillate organs. The organs corresponding to calyx and carolla are combined into a perianth. Near their base the stamens bear orange-colored glands which secrete nectar. The ovary is one-celled and contains a single ovule. The flowers of this race are very similar to those of the West Indian, and usually appear about the same time or a little later. The time of blooming of the Guatemalan varieties does not extend over such a long period as does the maturing of the fruit.

Fruit.—The fruit of the Guatemalan avocado is exceedingly variable in many of its characters. In weight it ranges from 4 to 48 ounces, with a general average of 16 ounces. In form it is commonly oval, but ranges from spherical to pyriform and even to curved-neck pyriform. The rind varies from a light green to dark purple and may be smooth, irregular, bumpy, rough, or even warty. Roughness is often more pronounced toward the stem end of the fruit. The rind of different varieties varies from one-sixteenth to one-fourth inch in thickness, and is usually hard and granular. The meat is golden yellow. In some varieties maturity can not be determined by color of rind or by pressure with the thumb and fingers on the firm surface. The stem will readily separate from ripe fruit upon being gently pulled.

Seed.—The seed is usually spherical in shape and is firmly lodged in the meat. Were it not fitted tightly in the cavity, its movement during shipment of the fruit would damage the pulp. It soon loses its viability, but when stored under proper conditions may remain viable for three or four months. The seed coats are thin and adhere closely to the cotyledons, even after their removal from the fruit.

PROPAGATION.

The Guatemalan avocado may be propagated by seeds, by budding, and by grafting. Seed propagation is nature's greatest method of producing variation, but it can not be relied upon to reproduce the variety. Standard varieties of avocados are maintained only by asexual methods of propagation, such as budding, inarching, and bark grafting. Nearly all of the early introductions into Hawaii came as selected seeds or seedlings and have produced fairly good fruit, but the seedling method of propagation has given few estab-

lished varieties. Standard fruits can be had only by asexual methods of propagating good varieties in large numbers.

Seed.—This method of propagation is of value principally for the production of rootstocks on which known varieties may be grafted. Seedlings may also be grown in an effort to produce new varieties, but can not be relied upon to perpetuate them. Many growers use this method of propagation because it is not difficult and they are satisfied to accept the results. Seedlings for the home garden are usually propagated in pots or boxes and upon attaining suitable size and vigor are transplanted to their permanent place. This period may vary from six months to a year. The seed should be selected from good fruit if vigorous seedling stock is to be produced.

The seeds should be washed clean and planted as soon as possible after their removal from the fruit, being set in earthen pots, seed boxes, or in seed beds in the open ground. One-gallon tin containers, such as are frequently discarded by pineapple factories, may be utilized to good advantage instead of earthen pots. In preparing the cans the tops should be trimmed and five or six large nail holes punched in the bottom for drainage. They should be filled with a potting soil consisting of four parts garden loam, two parts black volcanic sand, and one part thoroughly decomposed barnyard manure. At the station the potting soil is mixed and then given a thorough steam sterilization to destroy insect life, weed seeds, and fungus growth that may be present. One seed should be planted in each container, being placed with the pointed or upper part projecting above the surface. The plantings should be set in the open with the full sun upon them. Germination will take place within three or four weeks if the soil is kept sufficiently moistened, and the seedlings will attain budding and grafting size in 40 to 60 days. At this time the plants should stand 1 to 2 feet in height and have a stem diameter varying from one-half to three-fourths of an inch at the customary point for budding, 2 inches above ground.

Care of seedlings.—The seedlings should be protected from strong winds and kept far enough apart in good sunlight to avoid making spindling growth. Newly budded trees may continue growth in the same containers until they are 12 months from the planting of the seed without becoming seriously pot-bound. It is best to transfer them to larger containers if they begin to show injury from root confinement. Trees propagated in the above-mentioned way should be set in the orchard in the cooler months of the year.

Stock plants.—Seedlings of the avocado itself form the best stock upon which to grow desirable varieties. It is thought that budded avocados do best when stock and cion are of the same race, there being then a more natural union because of the similarity of their cell structures. Vigorous Guatemalan seedlings, for example, should be used as stocks for cions of desirable varieties of the same race.

Budding.—Shield budding, which is in reality a form of grafting, is now the most commonly used method of propagating varieties of avocados. Budding has long been practiced in the propagation of peaches, plums, etc., but its use in connection with the avocado is comparatively new, and the process has been found to be much more difficult with the avocado than with the other fruits. Experienced budders often succeed in developing only 10 to 25 per cent of the

buds into trees. With such varieties as the Taft and Fuerte, however, 95 per cent of the buds can be made to develop into trees.[6] Success is based upon a number of factors, including vigor of growth of cion and stock, a sharp-edged, thin-bladed, clean budding-knife, and the ability of the budder to perform the operation skillfully.

Bud wood.—The buds differ widely in character among varieties of the same race, and the selection of the proper sort of bud wood, especially of certain varieties, requires keen judgment. For this reason the budder should familiarize himself with the nature of the bud wood with which he is working. (Pl. II, fig. 1.) Only plump, mature buds which are ready to break into growth should be selected. Good bud wood is usually obtained from new branches which have become fairly mature. This stage of growth is reached in 6 to 10 weeks. Very little success is had with bud wood from soft tips. As soon as it is removed from the tree the bud wood should be wrapped in moistened sphagnum moss and oiled paper. When properly packed it has been known to remain in good condition for 40 days. Dampened cloth may be used successfully as a wrapper for such short periods as two or three days.

The process of budding.—In shield budding, a T-shaped or an inverted ⊥-shaped incision is made in the bark of the stock, preferably within about 2 inches of the soil. Unless the stock is too dry to be budded, the bark will readily separate from the wood when the bud is gently pushed in. The knife blade should be turned slightly forward in making the horizontal cut so that the surface from edge to back is sloping downward. This forces the bark away from the stock and leaves a sufficient opening to receive the bud. In cutting the bud, the thin, sharp blade should be drawn with a single, steady, sliding stroke, keeping the blade as nearly parallel with the bud stick as possible, making the cut surface flat and as little rounded as possible at the ends. Bud shields of large bud sticks are sometimes 2 inches long. The inside of the shield should be cut so as to possess a small portion of the sapwood. Part of the leafstalk should be left attached below the bud to hold the shield while it is being pushed into place. As soon as the bud shield is in position the whole should be firmly bound with strips of moist raffia, cotton twine, or cotton tape to prevent the delicate tissues from drying out. At the station raffia is used almost entirely for this purpose.

After the raffia has been wound several times above and below the bud to cover the horizontal and the vertical cuts of the T, the ends should be firmly tied in a drawing knot and clipped. The union should then be bound with waxed tape, the wrapping being done from the bottom upward, so as to prevent the entrance of water to the bud.[7] The waxed tape should be removed after 6 or 8 days and the raffia 12 or 14 days later. The raffia, however, should not be left on long enough to bind the native growth. As soon as the waxed tape is removed the trees should be topped back a few inches to force the new bud into growth. Along the stem axillary buds will then break into growth, some of which should be allowed

[6] Popenoe. Manual of tropical and subtropical fruits. New York. 1920.

[7] A low-melting paraffin wax, 118–120° F., put on with a brush to cover the bud and entire union, has been found equally as good as and of easier application than wax tape, and it fulfills the same function, remaining on until forced off by natural growth. The raffia should be cut when there is evidence of its beginning to bind.

to grow for a time to maintain an active flow of the sap. Four or five weeks later the top should be cut back farther, leaving few of the lower axillary bud growths. If the stock is cut back too heavily the first time, the eye may fall from the bud and leave a blind shield. As soon as the bud has made a growth of 3 or 4 inches it should be tied upright to the stem of the seedling or be stake trained. The remaining stub of the seedling stock should be cut back at an angle just above the bud and the cut surface sealed with grafting wax. This final cutting is made when the desired bud shoot has reached a length of 6 to 10 inches. (Pl. II, fig. 2.)

THE ORCHARD.

LOCATION OF WINDBREAKS.

In the Hawaiian Islands, where there is likelihood of high winds, it is essential that the avocado be grown in a sheltered location. The wood of the tree is brittle, and, like the flowers and the fruit, is easily broken. Windbreaks will hardly protect an orchard that steeply slopes toward the wind, but protection can be afforded when the slope is in the opposite direction. Temporary protection should always be given young trees, whether or not permanent protection is necessary. This may be supplied in the form of burlap which is tacked to stakes on the windward side of each tree. Better still is the planting of rows of pigeon peas between the rows of trees across the field. This method has been thoroughly tested both at the station and in the large Guatemalan avocado orchard of W. D. Baldwin at Haiku. The pigeon pea improves the soil in texture and fertility by its rich nitrogenous vegetation. The panax hedge (*Nothopanax guilfoylei*) also makes an excellent windbreak, growing upright to a height of 15 feet or more.

Large permanent windbreaks, when necessary, should be grown on the windward side of the orchard and should consist of such rapidly growing trees as the ironwood (*Casuarina equisetifolia*) and eucalyptus (*Eucalyptus robusta*). The mango (*Mangifera indica*), which withstands heavy winds, makes an excellent windbreak. Trees for shelter purposes should be started in a double row, being placed about 8 or 10 feet apart in the row, or even farther in the case of the mango, with the windbreak trees alternating in the row.

ARRANGEMENT OF TREES.

The trees should be so arranged in the orchard that the best results can be obtained from the smallest area. Budded trees always remain somewhat dwarfed, and they can be set from 20 to 30 feet apart. A commercial orchard can be satisfactorily arranged by setting the trees in rows 26 by 26 feet on the square, which will permit the growing of 64 trees to the acre. Some growers recommend that the trees be set 30 by 30 feet, which will allow 48 trees to the acre. The number of trees per acre varies, however, according to the planting method used. Any one of the several methods for arrangement of orchard trees as described in popular horticultural works may be used for the avocado orchard. The most important of these are the square, triangle, hexagonal, and quincunx, the first being the most commonly used.

Several varieties of avocado should be intermixed in orchard arrangement so as to permit of better pollination at blossoming time.

MACDONALD AVOCADO, ORIGINAL TREE (ACC. NO. 4191), JANUARY 1, 1923.

Brought to Honolulu as a germinating seed in 1895. Parent of a number of good varieties, the leading characters of which have remained true to the race of the mother parent tree.

FIG. 1.—AVOCADO BUDWOOD OF WINTER-BEARING VARIETIES. 1, FUERTE; 2, ISHKAL; 3, NIMLIOH; AND 4, BEARDSLEE.

Varietal characters are evident in budwood, and the close observer who makes a study of the avocado soon learns to identify varieties by it.

FIG. 2.—BUDDED AVOCADO TREES.

Seedlings are grown in gallon cans; if kept growing vigorously they will be ready to bud in about two months, after which it requires about six months to develop them into budded trees suitable for setting in permanent place.

KIND OF TREES TO PLANT.

Only grafted or budded trees which have thoroughly united with the stock and have made thrifty growth should be set. Pot-bound trees should never be used. Pot-grown trees which have been given the proper care afford greater opportunity for uniformity than is usually the case when the seedlings are grown and grafted in their permanent places in the orchard. Moreover, they can be removed from earthern pots or tin cans with less disturbance to their root system than is possible when trees are dug from the nursery rows.

WHEN AND HOW TO PLANT.

The most suitable time for planting the trees in most parts of the Hawaiian Islands is from October to December, when the warm weather has passed and the fall rains are due. If planted in late spring or summer they have the most trying months ahead of them for starting growth. Avocados, however, may be planted during any month with a fairly reasonable degree of success.

The holes for planting should be at least 3 feet across and 3 feet deep. Surface soil and sand which have been enriched with well-rotted barnyard manure should be placed in the bottom of the holes before the trees are set. Considerable sand should be incorporated with the soil if the soil has a tendency to be heavy, coral sand from the seashore being preferable for this purpose on account of its composition. The young trees should be inclined slightly toward the wind and set firmly at the same depth at which they stood before being transplanted, with the roots spread in their natural position. The soil immediately around the trees should be several inches lower than the natural surface to form a basin which will hold water until the trees have become firmly established. After planting, the trees should be liberally supplied with water.

A stake should be driven about 1 foot from each tree on the windward side to act as a support during the first two years of growth, and each tree should be firmly tied to the stake with a piece of burlap.

CULTURAL REQUIREMENTS.

SOIL.

In avocado culture one of the essential factors is the soil. The trees will thrive in either heavy or light soil provided it is well drained. Soils that are suitable for citrus growing are generally well adapted to the avocado. The culture of the avocado for commercial purposes should not be attempted in localities which can not be brought under irrigation or where there is little rainfall. Young trees require liberal quantities of water during their early years in order to maintain vigorous growth. The soil should contain an abundance of moisture at the time the fruit is setting and until several weeks after fruiting is over. The avocado tree is a subtropical evergreen and has no marked rest period. Soil-moisture must, therefore, be uniformly available throughout the year.

Preparation of the soil.—Preliminary preparation of the soil of the avocado orchard is just as necessary as for other kinds of fruits or for field crops. The land should be cleared of all growth, scattered rock, and débris, and then thoroughly plowed and harrowed,

before planting. Where plowing is impossible, large holes should be dug or blasted to sufficient depth to assure good drainage and ample feeding area for the young roots.

IRRIGATION.

Water for irrigation may be applied in different ways. The exact quantity necessary varies considerably with the different soils. Where only a few trees are to be watered, the basin system may be used. A separate basin is required for each tree. The soil should be left at its natural level for a space of several feet about the base of the tree. Outside of this area the basin should be dug to a depth of 6 to 8 inches, extending entirely around the tree, with a radius of several feet, varying according to the spread of the branches. Consequently it will be placed directly above the major portion of the feeding roots needing the moisture. The soil which is removed from the basin should be formed into a surrounding ridge to aid in holding the mulch and the water when the basin is filled. The mulch should consist of a coarse, strawy barnyard manure. In large orchards avocado trees may be watered to better advantage by the furrow system, such as is commonly used in irrigated commercial citrus orchards. The soil should be cultivated after each irrigation. Avocado trees that are surrounded by grass or other volunteer growth and are watered with a garden hose rarely get enough water to make satisfactory growth and are subject to irregular blooming, dropping of fruit, and occasionally to total crop failure.

TILLAGE.

From experiments made at the station and in private orchards in the Hawaiian Islands, as well as in Florida and California, it is evident that frequent and thorough tillage is essential to excellent fruit production. Associated with tillage is intercropping and the growing of cover crops.

COVER CROPS.

Orchard cover crops should be grown during the wet seasons in practically all parts of Hawaii. They prevent surface washing and retain much of the water of torrential rains until it has had time to soak into the earth underlying the trees. Another advantage of the cover crop is the green manure which it furnishes, thus returning humus to the soil. Among the legumes that can be used for this purpose are the pigeon pea (*Cajanus indicus*), cowpeas (*Vigna catjang*), mungo beans (*Phaseolus mungo*), soy beans (*Glycine hispida*), Crotalaria (*Crotalaria juncea*), white clover (*Melilotus alba*), and common vetch (*Vicia sativa*). Pigeon peas are the most commonly used in Hawaii. Of the two varieties of mungo beans, the yellow and the green, the former variety is preferred on account of its height and herbage. Although Crotalaria is as yet little used as a cover crop in Hawaii, it is deemed worthy of further trial. Several tests of common vetch at higher altitudes indicate that it will be of use as a cover crop in the highlands. Cowpeas have given the best results of the legumes as a cover crop in the station orchard.

INTERCROPPING.

The growing of other marketable crops between the rows is advisable, but they must not be planted close enough to the avocado trees to interfere with their development. When the rows are 24, 26, or 30 feet apart, papaya trees may be used as the intercrop at elevations below 500 feet and a considerable income derived from them before they become large enough to injure the avocados. The tomato is an excellent crop for interplanting, and the fruit usually brings a good price in the local markets. Such other crops as the sweet potato, string bean, pepper, squash, peanut, and alfalfa may also be grown successfully. At elevations of 1,000 feet or more, roselle (*Hibiscus sabdariffa*), poha berries (*Physalis peruviana*), chayote (*Sechium edule*), and water lemon (*Passiflora laurifolia*) can be satisfactorily used as intercrops. Sweet corn offers a possibility as an intercrop and would find an almost unlimited market locally.

When it is desired to grow two kinds of permanent crops, the avocado tree rows may be interspaced with rows of coffee trees. Guatemalan avocados and coffee can be grown in combination very well, since the requirements of the two crops are very similar and each bears at a different season.

PRUNING.

Well-grown Guatemalan avocado trees require little or no pruning other than the pinching out of tender buds which would become undesirable branches. The kind and amount of pruning varies with the different varieties. In most cases it is desirable to keep the tops low, with the lower branches shading the ground as much as possible. Such trees are less subject to the force of the wind than are high-headed trees and can easily be propped when necessary, while their lower branches help to conserve moisture and bring the fruit within easy reach of the gatherer. When these trees grow older, the lower branches should be gradually trimmed back and finally removed to make room for the upper larger ones which bend down. The aim should be to secure a strong symmetrical tree having well-spaced branches which will readily sustain heavy crops of fruit. A considerable portion of the top should be removed from trees that have become one-sided from exposure to continuous wind. Dead twigs in the fruit-producing area and dead branches in the interior of the tree should be cut out as also deadwood or branches which have been affected by wood-boring insects of the genus Xyleborus.

Avocado trees may be pruned to some extent at almost any time of the year if it is necessary to restrain the growth of the branches. Undoubtedly the best and safest time to prune is when there seems to be least activity of growth. Heavy pruning is likely to force vegetative growth rather than fruit wood.

Sharp pruning shears should be used for the removal of small branches and the pruning saw for large limbs. All wounds that are three-eighths of an inch or larger in diameter should be smoothed off with a sharp pruning knife and painted to prevent die-back or the entrance of insects. Asphaltum paint has been satisfactorily used where considerable pruning has been done. Preparatory to being used the asphaltum should be thoroughly melted and then

diluted with gasoline (after removal from the fire) until it forms a mixture that has on cooling the consistency of thick paint which hardens on drying.

FERTILIZERS.

Very little systematic attention has as yet been given the subject of fertilizing the avocado. No serious problems regarding fertilizer requirements have arisen during the short time the fruit has been under commercial cultivation. From experiments conducted at the station it has been found that the avocado tree responds readily to fertilizer in vegetative growth as well as in texture and flavor of fruit. Avocado trees of bearing age which were in serious condition have been restored to vigor and fruitfulness when given applications of barnyard manure either as a mulch in irrigation basins under the trees or when worked into the loosened surface soil above the feeding roots. In most of the experiments, however, water in abundance has doubtless been an important restoring factor. It is advisable to use caution in fertilizing avocado trees, particularly with highly nitrogenous fertilizers or such as will leave too much organic matter in the soil. Like heavy pruning, heavy fertilizing is likely to force vegetative growth at the expense of fruit wood and to result in a greatly diminished production of fruit for several years.

THE CROP.

TIME OF MATURITY.

The age at which budded Guatemalan avocado trees come into bearing depends upon the variety. Some varieties bear fruit in their third year, and practically all those worthy of cultivation should produce at least a few fruits in their fourth year. The season of maturity of the fruit of a variety may vary with climatic and other conditions under which it is grown, such as latitude, altitude, humidity, and the like. For example, the Tumin variety of the Popenoe collection matures its crop in February when grown at an elevation of about 1,000 feet at the Tantalus substation, Oahu, and from May to June when grown 5,100 feet above sea level in its native place of Antigua, Guatemala. With the combination of varieties from different environments, mature fruits may be obtained in Hawaii practically throughout the year.

HARVESTING.

Avocados picked when immature and allowed to ripen sometimes become edible, but are likely to be watery and insipid. The shipment of such fruit should not be encouraged, as it will soon injure a growing trade. Fruits which are purple when ripe do not usually develop their color until they reach the last stage of maturity. This fact may serve as a guide in determining the time of picking. It is rather difficult to determine the time of maturity of varieties which retain their green color. Close observation usually shows that such fruit undergoes a slight change in shade of skin and stem which indicates the proper degree of maturity. The grower will soon become familiar with the peculiarities of each variety and learn to make the proper selection at harvest time. If not picked when mature, the fruit of some varieties will remain on the tree for weeks and even for months after the normal season for harvesting has passed. In

other cases the seed sprouts in the cavity of fruits which are left too long on the tree.

Avocados should be cut from the tree and not pulled or broken off. Orange clippers are excellent for this purpose. The stem should be cut just above the point of attachment where it is enlarged. A step-ladder can be used in picking fruit from the higher branches and properly constructed long-handled pickers, for plucking the fruit from the top of the trees. In Florida, where the avocado is grown for shipment to distant markets, regular fruit pickers, having a bag attachment at the end of the pole, are used in harvesting avocados. Some growers collect the fruit in baskets.

PACKING AND MARKETING.

The present method of picking, packing, and marketing avocados in Hawaii is unsatisfactory even for local trade. Too often the fruit shows the results of rough handling. Fungus spores soon get a foothold if the stem is pulled out, and there is likely to be great annoyance in handling fruit which has been broken off with the stem adhering. The fruit should be carefully handled if the industry is to develop to desirable proportions.

In Florida the standard package for shipment of avocados is a well-made crate, the dimensions of which are 12 by 12 by 24 inches. Each crate holds from 18 to 36 fruits, depending upon their size. The crates are similar in shape to the standard California orange box and have a partition in the center. Fine excelsior is placed above and below each layer of fruit and between it and the box to prevent any possibility of shaking and to permit a slight circulation of air in the box. The Guatemalan varieties should be packed firmly in the crate, but not as tight as oranges are packed. Fruit so packed can be shipped short distances without refrigeration and long distances with refrigeration.

YIELDS.

Most local bearing trees of the Guatemalan avocado are seedlings. Budded trees have not as yet been in cultivation long enough to permit of their maximum production being known. In 1900 the original Macdonald avocado tree began to attract attention as a prolific yielder of good fruit in the winter months. Although the tree has been under rather close observation since that time, few definite records are available showing the number of fruits produced in a season. It is estimated that from 300 to 400 fruits have been produced in some seasons and occasionally few fruits in other seasons. A light crop is usually followed by a heavy one. The habit in fruit trees of producing heavy and light crops alternately has been overcome to considerable extent by good cultural methods. The original Macdonald tree produced a large crop in 1921, followed by a light crop in 1922. In January, 1923, it matured a crop of 300 fruits, which is a fairly large yield in view of the size of the tree and the little attention it has received.

The Kalua[8] avocado tree, located in Wailuku, Maui, at an elevation of about 280 feet above sea level is reported by its owner, Judge Kalua, as being prolific. A study made of this tree during the past two years shows that it is very productive under adverse conditions.

[8] Sometimes misspelled "Kailua."

A 17-year-old tree of the Bon variety produced a crop of about 500 fruits in 1922. These were sold on the tree for $100 and retailed on the local markets for 60 cents apiece.

The estimated production of fruit of a 14-year-old tree of the variety Wilder for the past few years has been between 250 and 300 fruits. Seven to ten year old trees of the Beardslee variety have made some very favorable records of several hundred fruits per tree per season. Both Wilder and Beardslee are inclined to produce heavy and light crops alternately unless carefully regulated.

CONTROL OF INSECT ENEMIES.

Insect enemies of the Guatemalan avocado are not numerous in Hawaii.

MEALYBUGS.

The avocado mealybug (*Pseudococcus nipæ*) is the most serious of the insect pests. Fullaway,[9] in writing of their control says the symbiotic relationship between ants and mealybugs is largely responsible for their dissemination and presents an added difficulty in attempting to cope with them. Trees infested with mealybugs lose most of their foliage and show a loss of vigor; young trees are killed.

Control.—Kerosene oil-emulsion sprays are the most effective means of control for avocado mealybugs. The following is the formula for making the emulsion:

Common laundry soap	pound	½
Kerosene (coal oil)	gallons	2
Water	do	1

The soap should be dissolved in water while it is boiling over a fire. The solution should then be removed to a safe distance from the fire and the kerosene added to it. The mixture should be violently agitated until it has a creamy consistency, thickens on cooling, and shows no trace of free oil on the surface. A perfect emulsion is best procured by charging and discharging the spray pump in the mixture for 10 minutes, the direct-discharge nozzle having an opening which will throw a strong stream. This is a stock solution, and when properly made and protected from air will keep for several weeks. When used, the stock solution should be diluted with water (1 part of the solution to 15 parts of water). The emulsion should be applied to the infested part of the tree with the spray pump.

Another oil-emulsion spray which is often used for mealybugs in much the same way as the kerosene-emulsion spray is San-U-Zay oil, which has the following formula:

San-U-Zay oil	part	1
Water	parts	35

The mixture should be thoroughly agitated by means of a wooden paddle before being applied as a spray. The oil separates when the emulsion is allowed to stand for several days, but the emulsified form is restored when a little salsoda is stirred in.

WOOD-BORING BEETLES (Xyleborus immaturus).

Wood-boring beetles often enter the trunk or larger branches where the wood is exposed following injury, and in many cases work into the live wood beneath the bark. Unless prevented, they will

[9] Hawaii Sta. Bul. 25, The avocado in Hawaii, p. 22. 1911.

soon kill the tree. Their presence is easily detected by the white, frost-like deposit which the exuding sap leaves on the outer bark after the moisture has evaporated from it.

Control.—Carbolic-acid emulsion has recently been used with success as a control measure at the station and also in private orchards. The emulsion is made as follows:

Crude carbolic acid	gallon	1
Common laundry soap	do	8
Water (hot)	do	8

The soap should be cut into thin shavings and dissolved in boiling water, after which the carbolic acid should be added to it. The whole should then be allowed to boil for a considerable time. Diluted with water (1 part solution to 20 parts water), this solution is used both as a wash and as a spray for the trees attacked.

Avocado branches showing the work of borers should be removed and burned. If the beetles have not progressed too far in their work of destruction, they may be dug from the trunk before the solution is applied. All scars should be covered with asphaltum paint.

GREEN CATERPILLAR.

The green caterpillar of the tortricid moth (*Amorbia emigratella*) occasionally injures the foliage of avocado trees, particularly young trees. The caterpillar is a form of leaf folder which draws the edges of the leaf together and then retreats temporarily into the shelter thus afforded. At feeding time it emerges and eats the tissues of the leaf. The adult moth has a wing expanse of about an inch and is of brown color.

Control.—The green caterpillar may be controlled by the use of arsenical spray.

Arsenate of lead (paste form)	ounce	1
Water	gallon	1
Or		
Arsenate of lead (powdered form)	ounce	½
Water	gallon	1

The spray should be applied as soon as there is evidence of injury from the green caterpillar and should be repeated as often as necessary. Arsenate of lead is much less likely to injure the foliage than is Paris green and it is more effective.

COMPOSITION OF THE FRUIT.

Although analyses do not indicate just what varieties of avocados it is best to grow, they do show in a general way the nutritive value of the fruit and thus help to determine its place in the dietary. A fruit containing a high percentage of one or more essential constituents may be undesirable because of peculiar flavor caused by some other constituent. In the Guatemalan avocado the proportions of the constituents change in each variety according to the degree of maturity of the fruits and vary in different years and in different localities.

Unfortunately very little data are available regarding analyses of the Guatemalan avocado. Analyses of a few locally grown varieties show no striking differences in composition between them and those tested in California. The following table affords a comparison of the composition of the edible portion of Hawaii-grown with that of California-grown Guatemalan avocados.

Comparison of composition of Guatemalan avocados grown in Hawaii and in California.

Variety.	Water.	Protein.	Fat.	Carbohydrates.		Ash.
				Crude fiber.	Nitrogen-free extract.	
Hawaii experiment station:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Nutmeg	63.58	1.22	26.73	2.04	4.72	1.71
Bon	73.13	1.60	18.72	1.65	3.56	1.24
Towse	70.38	.82	22.62	1.36	3.43	1.39
Cockett	73.84	1.10	19.50	1.51	2.78	1.27
Acc. No. 4922	75.82	2.53	14.85	1.62	3.84	1.34
Wilder[1]	76.81	1.31	15.87	5.15		.86
University of California:						
Blakeman	76.02	2.88	16.35	3.77		.98
Sharpless	76.73	2.15	15.73	3.69		1.70
Lyon	76.78	2.48	16.31	4.38		1.05
Solano	90.62	1.27	3.85	3.64		.62
Fuerte	60.86	1.25	29.14	7.40		1.35

[1] The analysis of Wilder's Guatemalan No. 1 was made by the University of California and furnished through the courtesy of G. P. Wilder, Honolulu.

Fat.—The analyses show that the avocado contains a very high percentage of fat and constitutes an important source of vegetable oil. The Nutmeg, a variety of Hawaiian origin, analyzed 26.73 per cent crude fat. In one analysis the variety Fuerte gave a fat content in California of 30.72 per cent. The only fruit comparable with the avocado in fat content is the olive, and a number of analyses indicate that the avocado ranks higher in fat content than does the average or commonly used olive. The digestibility of the avocado has been found to be equal to that of butterfat and not below that of beef fat.

Protein.—The protein content of the Guatemalan avocado averages about 1.5 per cent, which is somewhat above that of most other fruits.

Ash.—Five varieties of locally grown Guatemalan avocados which were analyzed by the Hawaii station showed an average ash content of 1.39 per cent. This is much higher than is found in other fresh fruits, and is somewhat higher than the ash content of a much larger number of varieties of several races of avocados which were analyzed in California. The analyses as made in California give the average percentage of pure ash of the edible portion of the avocado as 1.14, which contrasts with the averages of other California fruits, as follows: Grapes, 0.5 per cent; prunes, 0.565; plums, 0.524; apricots, 0.484; nectarines, 0.49; figs, 0.6; lemons, 0.535; and oranges, 0.5.

The various mineral substances are contained in the ash of a fruit, and in the study of dietetics it is important to know what kind of mineral a fruit may contain when used as a food. There should be proper balance between base-forming and acid-forming elements in the dietary. Nuts, for example, belong to the foods furnishing the acid-forming elements in excess and for this reason should be used in combination with certain fruits. Investigations show that the avocado belongs to the class of foods yielding an excess of base-forming elements, while in the ash of cereals, nuts, meats, eggs, and the like phosphoric acid greatly predominates. This element is found only in relatively small amounts in avocados and most other fruits. In this connection it is well to note that the avocado has a low lime, as well as phosphoric acid, content, and therefore has no great amount of bone building material.

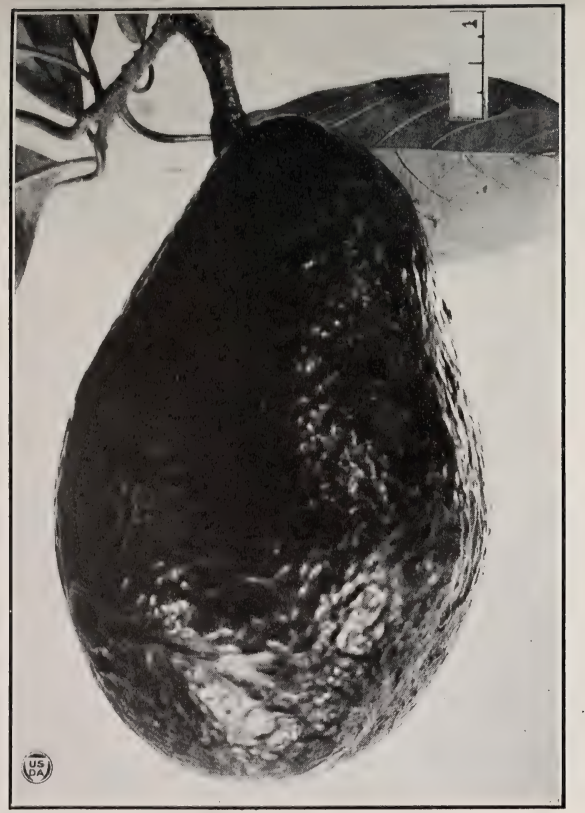

FIG. 1.—MACDONALD AVOCADO (ACC. NO. 4191). TAKEN FROM THE ORIGINAL TREE AT 1402 PUNAHOU STREET, HONOLULU.

Although at an elevation of less than 100 feet, the crop ripens during the winter months and normally consists of 200 to 400 fruits. Since the tree has become mature the fruit stems are shorter than formerly.

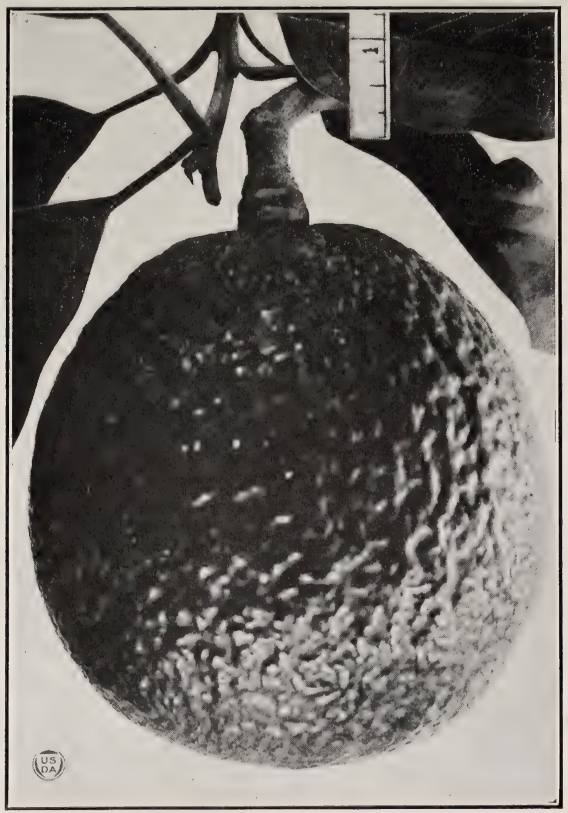

FIG. 2.—FRUIT OF THE NUTMEG AVOCADO (ACC. NO. 4076).

Originated from a seed of the Macdonald avocado at the Hawaii Station in 1907. In size it averages double that of the mother parent, and its quality is quite as good.

FIG. 1.—WILDER (ACC. NO. 4540).

Has gained considerable reputation for its fine quality. Original tree was grown by Gerrit P. Wilder. The tree is large, vigorous, and prolific. The fruit is unlike that of the mother parent, the Macdonald, in size, smoothness of surface, and color which remains green at full maturity.

FIG. 2.—BEARDSLEE (ABLES, ACC. NO. 4075).

One of the leading varieties propagated by budding in Hawaii. It is of excellent quality. This variety should be interplanted among several other varieties blossoming at the same time to give a more perfect pollination and eventually a more regular fruit production than is the case otherwise.

FIG. 1.—THE KALUA (ACC. NO. 3413).

A favorite on account of its long fruiting period, November to March. The original tree was one of the three brought to Hawaii by Admiral Beardslee in 1895.

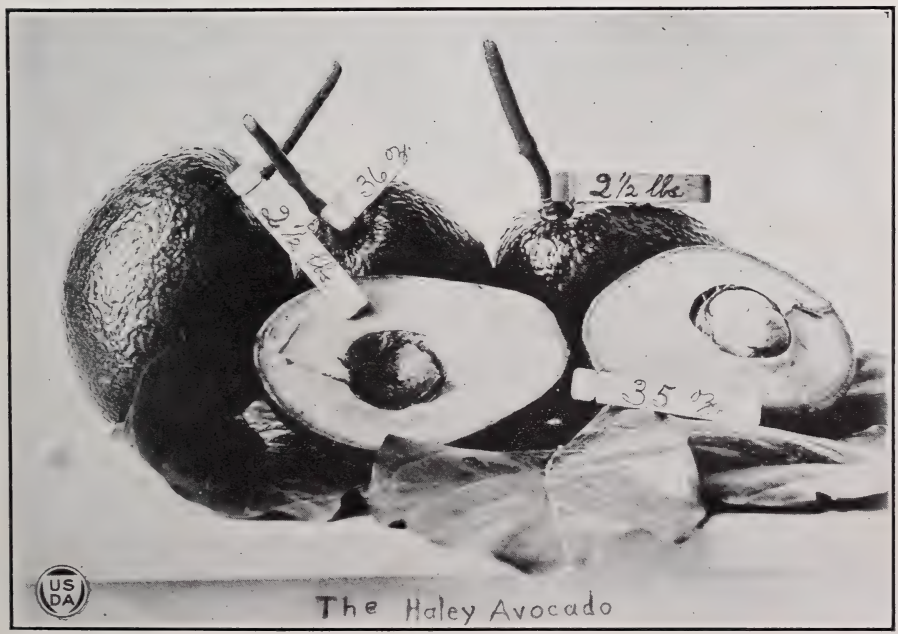

FIG. 2.—THE HALEY (ACC. NO. 4821).

Comes into bearing at an early age, and the fruit has very desirable qualities.

FIG. 1.—THE CASE (ACC. NO. 4705).

Tree is one of the most prolific in Hawaii, and the fruit is of splendid quality. It matures during the winter months even when growing at lower elevations.

FIG. 2.—THE BON (ACC. NO. 4820).

Tree is very productive. Seed averages large, but the fruit is a favorite on account of its excellent flavor.

Carbohydrates.—The total carbohydrate, including crude fiber and nitrogen-free extract, is not high in the avocado as compared with that of many other ripe fresh fruits. The crude fiber or solid matter remains far greater than is noted for most other fruits. The avocado contains a small amount of sugar, of which only about 50 per cent is saccharose. The studies of the avocado made by Prinsen-Geerlings give the total sugars as 1.72 per cent in the proportion of 0.4 per cent glucose, 0.46 per cent fructose, and 0.86 per cent saccharose.

USES.

The avocado is used in Hawaii in many ways. It is served on the half shell, for which purpose it is well adapted, the flesh being scooped out with a spoon. The fruit is also cut in halves or quarters, depending upon its size, and served with seasoning or dressing, and it is served with or immediately following the soup course. The avocado is also commonly eaten as a salad, being sliced or cut into cubes and served with salt and lime juice or with salt and vinegar to bring out the flavor. Mayonnaise, which contains about 95 per cent oil, should not be used with avocados, because the latter has an oil content of about 20 per cent. The delicate flavor of the fruit is lost when mayonnaise is used, and especially if it is served with catsup, cocktail, celery, nuts, or onions, regardless of the fact that various recipes recommend their use with the avocado.

In its native land the avocado is greatly liked by the Indians, who break the fruit in half, season the pulp with salt, and scoop it out with tortillas (corn cakes).

In summer, when there is an overproduction of the West Indian variety, the avocado is successfully fed to hogs and laying hens in parts of Hawaii.

EXPERIMENTS IN PROGRESS.

The objects of the Guatemalan avocado investigation begun by the station in 1918 are to introduce new varieties of the hard-shelled type, determine the best conditions of their culture in Hawaii, test a number with the hope of being able to select a group maturing high-grade fruit throughout the year, and encourage the culture of budded varieties so that there will be established a standard fruit for commercial purposes as well as for the home orchard.

The plantings have been made in a wooded valley on the slopes of Tantalus, where the soil is deep and rich, being a well-drained decomposed black volcanic sand. The elevation at this place is about 1,000 feet, the climate is cool, and the rainfall suitable for growing the avocado. In fact, the conditions are intermediate in relation to those throughout the Territory where the Guatemalan avocado is largely grown. The first trees were set out in May, 1919. Of 22 varieties received by mail from the United States Department of Agriculture, all but four survived the long journey and are now making fairly good growth. The varieties under trial and their identification numbers are as follows:[10]

[10] For a detailed description of these varieties the reader is referred to U. S. Dept. Agr. Bul. 743, The avocado in Guatemala, pp. 43–69, copies of which may be had from the Superintendent of Documents, Washington, D. C., at 30 cents each.

Guatemalan avocados of the Popenoe collection growing at the Tantalus substation.

Varieties.	S. P. I. number.	Varieties.	S. P. I. number.
Akbal	45505	Manik	45560
Benik	44626	Nimlioh	44440
Kanola	43560	Tertoh	44856
Kayab	44681	Ishim	45562
Nabal	44439	Ishkal	43602
Pankay	44785	Kashlan	43934
Chisoy	43935	Mayapan	44680
Coban	43932	Panchoy	44625
Kanan	45563	Tumin	44627

Pankay, Nabal, Ishkal, Panchoy, and Tumin blossomed during March, 1922. Tumin was the only variety to set fruit, seven of which reached maturity in February and March, 1923. This variety was the first of the Popenoe collection to fruit at the experiment station and appears to have qualities of considerable promise. The orchard has been kept well cultivated, and the trees have been sprayed on several occasions to control the avocado mealybug and the leaf folder.

In connection with the above-mentioned experiments, a suitable technique for the pollination of locally grown varieties is being determined in the hope of uniting desirable characters of different varieties.

In another section of the Tantalus substation orchard 50 seedlings of the Macdonald avocado are being grown to permit a study of the natural variation that may occur. The remarkable variation that has already taken place with the original Macdonald avocado tree in the production of the varieties Wilder, Beardslee, Nutmeg, and possibly others, indicates that this variety is particularly subject to variation in desirable directions. In this connection it may be noted that the Macdonald avocado tree is located in a large backyard where no other trees of Guatemalan type grow, and it was the only one of its kind on the island of Oahu during the years when seeds grew producing the above-mentioned varieties. There were in the yard, during that time, from 1 to 7 avocado trees of West Indian type, but these were located from 50 to 300 feet away on at least three sides of the Macdonald tree. There were also West Indian avocados in other parts of the locality, some of which were in blossom at the same time the Macdonald tree was in bloom. Possibly the Macdonald was pollinated by these trees, which fact would account for the variations of form, color, and other characters in the progeny. The characters of the mother parent, the Macdonald avocado tree, greatly predominate, however. If the Guatemalan tree was entirely self-pollinated, then its seedling offspring have varied remarkably in desirable directions. This problem is being investigated.

The Wilder hybrids, consisting of the varieties Lahi, Calabash, Ilialu, Lehua, and Kinau,[11] are a very interesting and valuable group. All the crosses were made by Gerrit P. Wilder in the spring of 1914. The Guatemalan variety Wilder was crossed with West Indian pollen and the seedling trees resulting were set in the late

[11] These Hawaiian names have the following meanings: Lahi, thin; Calabash, shaped like a calabash; Ilialu, rough rind; Lehua, red; and Kinau, name of a princess.

fall of that year at "Esbank," the old Wilder home, 60 Judd Street, Honolulu. The five trees fruited in their fifth and sixth years, producing fruit of desirable quality, indicating their worth for propagating asexually as varieties. The trees vary somewhat in appearance, mainly in shape of tops. The foliage of all has the apparent characters of the Guatemalan. The fruit of each tree differs from that of the others, mainly in shape and character of rind, some being warty and others smooth. All the varieties mature their fruit either in late fall or early winter. The group is particularly interesting to plant breeders and shows the great possibilities for creating new and valuable varieties of avocados.

The following brief outline shows the relation of varieties as to parent trees and their progeny:

Macdonald (Acc. No. 4191)[12]
- Wilder (No. 4540; hybrids)
  - Lahi (No. 4926).
  - Calabash (No. 4674).
  - Ilialu (No. 4696).
  - Lehua (No. 4695).
  - Kinau (No. 4675).
- Nutmeg (No. 4076).
- Beardslee (No. 4075).
- Haley (No. 4821).
- ——— (No. 4922).
- Holt (No. 4819).
- Towse (No. 4818).
- ——— (No. 4924).
- Bon (No. 4820).
- McInerny, and several others.

Kalua (Acc. No. 3413)
- Case (No. 4705) — Cockett (No. 4817).
- ——— (No. 4815).

DESCRIPTION OF VARIETIES.

THE MACDONALD AVOCADO.

The Macdonald avocado (No. 4191) (Pl. III, fig. 1) began to attract attention probably as early as 1900. At first it was slow to meet with favor probably because of its warty rind and its size, which was small when compared with that of the West Indian avocado. When interested persons began growing its seedlings, however, they were soon attracted by the wide variation in the progeny and by the exceptionally fine fruit. Macdonald is an excellent shipper and has fine keeping qualities, the fruit remaining in a perfect state of preservation when kept at ordinary room temperatures for two or three weeks after harvesting.

Description of tree.—Upright and spreading, reaching a height of 40 feet and a spread of top of 30 feet in 30 years. The foliage is generally scant, dark green in color, and the leaves average small for a Guatemalan. Each fruit hangs separately on a long stem, often 12 inches in length. The tree often carries fruit over through the blossom period of the following season.

Fruit.—Form, spherical; color, rich, dark purple on ripening; surface, warty, very rough; rind, thick and granular, forming a firm, shell-like covering. (Pl. X, fig. 1.) Total weight, 12 ounces to 1 pound; flesh, yellow, varying to green toward the rind; texture, buttery and without fiber; flavor, rich and nutty. The seed is small to medium, tight in the cavity, nearly spherical in form, covered with two tight-fitting coats; weight, about 2 ounces. Season of

[12] The accession numbers under which most of the varieties have been propagated at the station are also given in the outline and descriptions.

maturity of fruit, from November to April, varying somewhat according to elevation.

WILDER.

The seed of the original tree of the Wilder (No. 4540) (Pl. IV, fig. 1) was obtained by Gerrit P. Wilder from F. W. Macfarlane, who lived on the Wiedemann place, now known as the Macdonald Hotel. Mr. Wilder planted the small seedling tree in his private garden at 1930 Ualakaa Street, in Makiki, Honolulu, in 1900. Although the tree grew vigorously for eight years and bore fruit abundantly, it gradually began to show signs of unsatisfactory soil conditions, and new trees were propagated from it by inarching on seedling rootstocks. The variety was maintained through the inarching progeny from which there has been developed a large number of varieties. When grown in proper environment the Wilder is a vigorous tree of rather upright growth and produces an abundance of fruit of excellent quality. The variety is easily propagated by budding. The fruit ripens during October, November, December, and January.

Fruit.—Form, almost spherical or slightly elongated; color, olive green; rind, surface slightly undulated, so thick as to be shell-like; weight, 1¼ pounds; flesh, yellow, tinged to green next to the rind, nutty in flavor, and free from fiber; seed, larger than the ideal, tight in the cavity, covered with skin but a perfect freestone. Keeping qualities of the fruit are very good.

LAHI.

The original tree of the Lahi avocado (No. 4926) was a cross between the Wilder and the West Indian, produced in 1914, and the seedling set at "Esbank," the old Wilder home, 60 Judd Street, Honolulu. It began to fruit lightly in its sixth year. It is carrying a good crop at present (1923). Each fruit grows on a long stem and matures in November and December.

Fruit.—Form, oblong oval; weight, 18 ounces; color, green at maturity with whitish-green specks on entire surface. Surface, slightly bumpy, smoothed over; rind, about one-sixteenth inch thick, leathery, separating from flesh easily at maturity. The flesh is yellow, smooth, free from fiber, rich, oily, and of nutty flavor. The seed averages about 3 ounces, is tight in the cavity; cotyledons, covered with two tight coats which adhere to seed on removal from fruit.

CALABASH.

The Calabash avocado (No. 4674) is growing in the yard of S. G. Wilder, where it was planted in 1914. (Pl. IX, fig. 1.) It is a vigorous tree of medium size and began to fruit in its sixth year. Trees of the variety have been propagated by budding. Its desirable flavor indicates that this sort is worthy of cultivation.

Fruit.—Form, almost oval, but slightly narrowing at stem end, giving the fruit a calabash shape. In size it is medium, weighing about a pound; color, dull green, darkening almost to black about the stem end upon maturing; rind, thick and shell-like, surface undulating to roughness around the stem end; the flesh is very yellow, varying to green near rind; slightly fibrous; rich and nutty in flavor; seed, medium to large, about 3 ounces in weight and fits tightly in the cavity.

FIG. 1.—ILIALU (ACC. NO. 4696).

A splendid keeper. Will remain on the tree for a considerable time after maturing enough to pick.

FIG. 2.—THE COCKETT (ACC. NO. 4817).

This large purple avocado is a cross between the Case and the West Indian. The fruit indicates characters of size, reduced thickness of rind, and a seed slightly loosened in the cavity, all of the latter race.

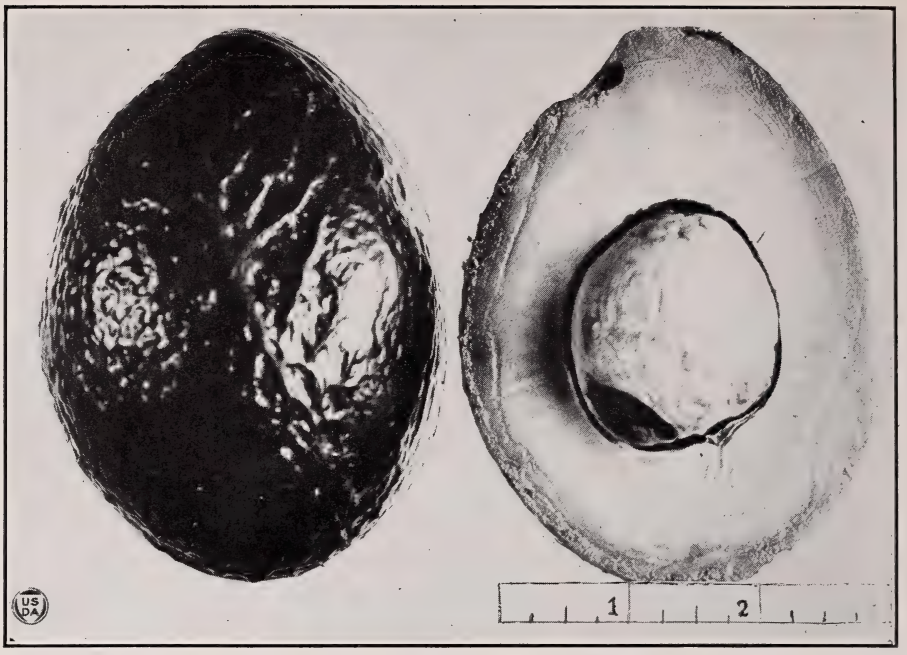

FIG. 1.—LEHUA (ACC. NO. 4695).

Fruit is large and has many points in its favor. The percentage of edible pulp particularly is high.

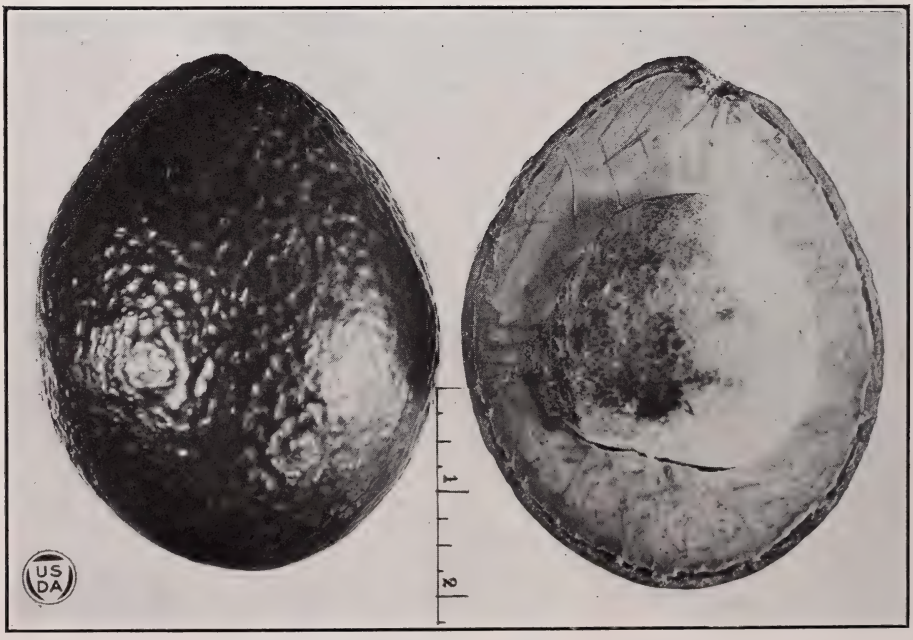

FIG 2.—THE HOLT (ACC. NO. 4819).

This fruit is the favorite variety of Valentine Holt, horticulturist, Honolulu. It is a second generation from the variety Macdonald.

FIG. 1.—A 9-YEAR-OLD HYBRID TREE OF THE VARIETY CALABASH (NO. 4674), WHICH IS MATURING A CROP OF 150 FRUITS.

FIG. 2.—THE TOWSE (ACC. NO. 4818).

A large, purple, pyriform fruit having a very thick rind. Note the characteristic radiating scars which are peculiar to several varieties of avocados.

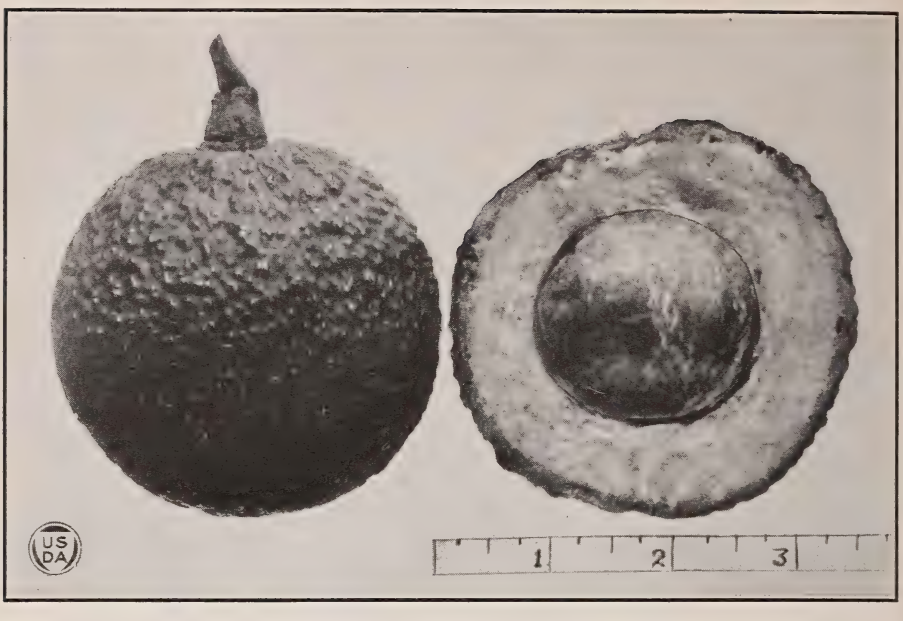

FIG. 1.—THE MACDONALD (ACC. NO. 4191).

The thick, shell-like rind of this fruit is a strong protective feature against insect pests: it also greatly prolongs the period of time that the fruit may be held on the market.

FIG. 2.—KINAU (ACC. NO. 4675).

A new variety of which the Macdonald is a grandparent. The high quality of the fruit indicates that it is one of promise.

ILIALU.

The Ilialu avocado (No. 4696) (Pl. VII, fig. 1) was planted at "Esbank," 60 Judd Street, Nuuanu Valley, Honolulu, in 1914. The tree, while not large, is healthy and vigorous and produced its first crop at 7 years of age (1921). The fruit is well distributed on the tree and does not fall easily after it matures.

Fruit.—Pyriform in shape; weight, 13 ounces to 1 pound; surface color, dark green when the fruit is ripe; rind, thick, rough, granular shell; flesh, fiber free, firm, and fine grained; flavor, good; seed, of medium size, tight in cavity; keeping and shipping qualities, excellent.

LEHUA.

The Lehua avocado (No. 4695) (Pl. VIII, fig. 1) grows on the residential property of S. G. Wilder at "Esbank." The tree produced its first fruit in 1921, at 5 years of age, is vigorous and healthy, and gives considerable promise as a new variety.

Fruit.—Form, oval; size, medium; weight, 1 to 1¼ pounds; color, dark mahogany; surface, irregular, undulated to bumpy, each fruit usually possessing a characteristic radiating scar. The rind is rather thick and shell-like, varying from one-eighth to three-sixteenths inch in thickness and is very coarse and granular. The flesh is fiber free, yellow, buttery, and of a pleasing nutty flavor. The seed is covered with two tight-fitting coats and is tight in the cavity.

KINAU.

The Kinau avocado (No. 4675) (Pl. X, fig. 2) grows in the yard of S. G. Wilder, and it produced its first crop in 1921, is healthy, and gives much promise as a new variety.

Fruit.—Form, oval; color, bright green; surface, very irregular; rind, thick and shell-like; weight, 14 ounces to 1 pound; flesh, fiber free, light greenish yellow, and of fairly rich flavor; weight of seed, about 2 ounces; two coats tight in cavity; keeping quality, very good.

NUTMEG.

The Nutmeg avocado (No. 4076) (Pl. III, fig. 2) was grown at the experiment station in 1907 under accession No. 1035.

Fruit.—Form, nearly spherical, slightly oval to pyriform; color, dull green; surface, very rough, particularly near the stem end; rind, medium in thickness, tough and hard; total weight, 26 ounces or more; flesh, light yellow, tinged to green near rind; texture, smooth and fine grained with very little fiber; flavor, excellent; seed, large, tight in cavity, and weighs about 6½ ounces. (For analyses, see table, p. 16.)

BEARDSLEE.[13]

The original Beardslee avocado (No. 4075) (Pl. IV, fig. 2), more commonly known as "Ables," was grown from a seed of the Macdonald variety. It was planted December 18, 1911, by L. C. Ables in his home gardens at 1627 Kewalo Street, Honolulu. It is known to have produced a crop of fruit within four years after planting. The season of maturing the fruit varies from late fall to early

[13] Originally, but erroneously, spelled "Beardsley."

winter. The tree is of upright and rather dense habit, a regular and prolific bearer. Many trees of this variety have been propagated by budding. The fruit is the largest and most perfect of all the Guatemalan varieties that have come under observation at the station. It has been referred to by good authority as the best of its race in Hawaii. The variety was named Beardslee in 1919 in honor of the man who introduced the seed of the parent tree into Hawaii, but it seems to be generally known locally as the Ables.

Fruit.—Form, oval to pyriform; weight, 1½ to 2½ pounds; color, purple on the surface when ripe; rind, thick and shell-like, granular, woody, and with a pebbled outer surface. The flesh is yellow tinged, with green next to the rind; texture, fine grained with a trace of fiber at the base; flavor, rich and nutty; seed, small and tight, or nearly so, in the cavity; weight of seed, 2 to 2½ ounces; total edible portion averages about 71 per cent.

HALEY.

The Haley avocado (No. 4821) (Pl. V, fig. 2) is a seedling of the Guatemalan race which was planted in Hawaii in 1913. It is grown on the ranch of Haley Bros., Pupukea, Oahu. The trees are prolific, coming into bearing about the third or fourth year, and producing fruits in clusters. The fruit ripens at lower elevations in November and December. Many trees have been propagated from this variety by W. H. Haley, 2621 East Manoa Road, Honolulu.

Fruit.—Size, 6 inches in length, 4½ inches in diameter; weight, 35 to 40 ounces. Form, oval to obovate; rind, thick, tough, and granular; surface, rough, green in color, with a slight purplish tinge upon fully ripening; flesh, fiber free, creamy yellow; flavor, rich, nutty; seed, small to medium in size, and fits tightly in the cavity.

HOLT.

The Holt avocado (No. 4819) (Pl. VIII, fig. 2) is growing in the rear of the residence at the northwest corner of the intersection of Makiki and Lunalilo Streets, Honolulu. It was about 7 years old in 1921, in healthy condition, and gives promise of being a good winter-bearing variety.

Fruit.—Form, varying from oval; color, shiny green when ripe; surface, undulated but smooth; rind, thick, firm, and shell-like; total weight, about 1 pound 3 ounces; flesh, fiber free, yellow, firm, buttery, and of a very good, nutty flavor; seed, rather large, weighing about 5 ounces. This variety is well worthy of bud propagation.

TOWSE.

The Towse avocado (No. 4818) (Pl. IX, fig. 2) is growing on the south side of the residence of E. Towse, 1105 Eleventh Avenue, Kaimuki, Honolulu. In 1922 the tree was large and spreading, and reached a height of about 45 feet. It is a prolific bearer and produces large attractive fruit which matures in November and December.

Fruit.—Form, pyriform; size, large, weighing about 26 ounces; color, purple; rind, three-sixteenths inch in thickness, bumpy, usually bearing the typical radiating scar-like marking; flesh, fiber free,

light yellow, and of good flavor; seed, large, weight 6¾ ounces, and fits tightly in cavity. (For analyses, see table, p. 16.)

BON.

The Bon avocado (No. 4820) (Pl. VI, fig. 2) is supposedly a seedling of the Macdonald. It grows in the yard of E. Towse. The seed was given to and planted in 1908 by S. D. Koki, former owner of the Towse property. At present the tree is about 45 feet high and of rather upright form. It is very prolific, often producing 1,000 fruits in a season. The fruit ripens in November and in early December. Judging from the appearance of the foliage and fruit, it is thought that the tree is a hybrid between the Guatemalan and the West Indian type of avocada.

Fruit.—Form, oval; size, medium; weight, about 23 ounces; color, shiny green; rind, medium in thickness, rather smooth on surface; flesh, fiber free, rich, light yellow, rather dry but appetizing; seed, large, weighing about 5¾ ounces. (For analyses, see table, p. 16.)

KALUA.[14]

The Kalua avocado (No. 3413) (Pl. V, fig. 1) is reported to be in fruit almost every month of the year. A number of seedlings producing fruit of fine quality have been grown from the seed of this tree. Both original and progeny are winter bearing.

Fruit.—Pyriform in shape, shiny green in color, turning lighter green on ripening; averages about 12 ounces in weight. The rind is thick, smooth outside and granular within. The flesh is light yellow, averages about three-fourths inch in thickness, is buttery, and of a fairly good flavor. This fruit is a splendid keeper. The seed is of medium size, weighing about 2 ounces, and is tight in the cavity.

CASE.

The Case avocado (No. 4705) (Pl. VI, fig. 1) was planted in the garden of D. H. Case, at Wailuku, Maui. The tree has always been vigorous and prolific, flowering in February and March and fruiting from October to March. The fruit varies considerably from the Kalua avocado, having characters that are superior to the latter and some fruits that curve too much. The Case avocado in its third year produced 25 fruits; in its fourth year, 35 fruits; and in its fifth and twelfth years, heavy crops. No record has been kept of its yield from the fifth to the twelfth year. Seedlings from the Case have developed fruit of fairly good quality and showed very little of the curved or pyriform shape.

Fruit.—Long, curved neck, pyriform; size, 7 inches in length; color, shiny dark green; surface, varying from smooth, undulated, to wrinkled at the neck near the stem; rind, one-sixteenth inch or more in thickness, forming a granular shell; average weight, between 16 and 18 ounces. Flesh, light yellow, shading to pale yellow near the rind. Texture, buttery without fiber; flavor, nutty, approaching closely that of the ideal; seed, small considering the size of the fruit, and weighs about 1½ ounces, fits tightly in the cavity and is a free-

[14] Sometimes misspelled "Kailua."

stone. Case is one of the best to propagate at present, because it has a long winter-fruiting period and is prolific and vigorous.

COCKETT.

The Cockett avocado (No. 4817) (Pl. VII, fig. 2), grown by Mrs. Pia Cockett, Wailuku, Maui, fruited in its third, fourth, and fifth years. The fruit matures in November and December.

Fruit.—Form, oval to pyriform; size, large, weighing 2 pounds; color, purple with greenish cast; surface undulated but smooth; rind one-eighth inch in thickness, tough, and leathery; flesh, fiber free, smooth; color, yellow tinged with green; flavor good; seed, large, weighing 4¼ ounces, almost filling cavity.

FUERTE.

The Fuerte avocado (No. 4559) originated at Atlixco, Puebla, Mexico. Although it is generally classed with the Guatemalan varieties, it is now believed to be a natural hybrid between the Guatemalan and Mexican races. The variety produces its fruit during the winter months. Bud wood of the variety has on several occasions been introduced into Hawaii by the station through the United States Department of Agriculture, and probably also by W. D. Baldwin of Haiku, Maui. Trees of the several introductions are now to be found in various parts of the Territory. Trees in the orchard of C. Miller, cooperator of Kaneohe, Oahu, produced some fruit in December, 1922. Judging from its hardiness in California, it is thought that the tree will make its best growth in the agricultural areas at higher altitudes in the islands. It is a favorite with many growers in California on account of its hardiness and high-grade fruit.

Fruit.—Form, pyriform to oblong, not necked; size, medium; weight, 10 to 16 ounces; length, 4 to 4½ inches, greatest breadth 2½ to 2⅞ inches; stem, inserted obliquely in a small shallow cavity; surface pebbled, somewhat wrinkled around the stem end; color, dull green with numerous small yellow dots; rind, about one-sixteenth inch in thickness, pliable and leathery in texture; flesh, rich creamy yellow in color, greenish near the rind; very rich flavor; quality excellent; seed, small, tight in cavity, seed coats closely surrounding the cotyledons.

TAFT.

The Taft avocado (No. 4565) originated as a seedling at Orange, Calif., and was first propagated in 1912. Several introductions have been made into Hawaii, but it is not known as yet what their productiveness will be.

Fruit.—Form, broad, pyriform, slightly necked; size, medium to large; weight, 14 to 24 ounces; length, 5 to 5½ inches; greatest breadth, 3¾ inches; surface, undulating to roughened around the stem end; color, deep green with numerous yellow dots; rind, thick, granular, and rather pliable; flesh, firm, smooth, light yellow in color; flavor, rich and pleasant, quality very good; seed, medium size, tight in cavity with seed coats adhering closely. Season for ripening varies from summer to late fall, depending upon locality.